Art. XVII.—*On the Variations in the Spinal Nerves of Hyla aurea.*

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(Communicated by Professor Baldwin Spencer).

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During the years 1893 and 1895 there appeared two papers by Dr. Hermann Adolphi, on the Variations of the Spinal Nerves of three of the European Anura, *Bufo variabilis*, *Pelobates fuscus*, and *Rana esculenta*. Comparatively little being known of the more minute details in the morphology of the Australian Amphibia, it was the wish of Professor Spencer that I should undertake a similar work in connection with some of our Australian forms. Accordingly, in April of this year, I commenced my observations on the nerves of *Hyla aurea*, the common green frog of Victoria, in the Biological Laboratory at the Melbourne University, and my thanks are due to Professor Spencer for his kindly help and advice given during the progress of this work.

On each side of the spinal column there are given off generally, ten nerves, as in the European forms, *Rana esculenta*,* and *Bufo variabilis*.† The first nine pairs, as usual pass through the intervertebral foramina, and the tenth pair through the canalis coccygeus in the urostyle. Occasionally in *Hyla aurea* there is found an eleventh nerve on each side, which, like the tenth to which it is posterior, passes out by a foramen in the urostyle.

As in the Anura generally, there is no representative of the first spinal nerve or sub-occipital, shown by Fürbringer to be present in the Urodeles, where it passes out between the skull and first vertebra; and in *Pipa dorsigera*, among the Anura, there piercing the first vertebra.

Nerve II., the Hypoglossal, is somewhat thin, and passes out between vertebræ I. and II. It then runs in a straight line

* Ecker: Anatomy of the Frog (English Translation, Haslam), p. 175.

† Adolphi: Morphologisches Jahrbuch, 1893, p. 316.

toward the side of the body for some distance, and turning sharply, often at an angle of almost ninety degrees, runs forwards to supply the muscles of the tongue. In a very few cases I observed that the hypoglossal divided into two parts which united again a little farther on, leaving a space through which the carotid artery passed towards the head. Between the hypoglossal and pneumogastric nerves there passed in one or two instances a twig of communication which, however, was very fine. Haslam mentions a similar connection as having been described by Hoffmann for *Rana*,* though he himself has not noticed it. The relations of II. with the brachial plexus are varied. Most frequently II. has no connection with the brachial plexus as stated by Adolphi for *Bufo variabilis*. Sometimes a branch passes from II. to join either III. itself, or else the coraco-clavicular branch of III. (cf. *Rana esculenta*, as stated by Weidersheim, Fürbringer, and Hoffmann).† In a few instances in *Hyla aurea*, we find that II. is fused with III., and where this is the case, a nerve corresponding in destination to II., and composed also chiefly of II. fibres, leaves III. to run forwards at the same position as that in which II. ordinarily turns forwards. In one specimen, II., divided into two equal parts at its exit from the intervertebral foramen, the anterior half passing out freely, while the posterior half fused with III. as above, leaving it again to join the anterior part as it turned forwards. According to Ecker‡ this fusion is not uncommon in *Rana*.

III. is the largest of all the spinal nerves. It passes outwards from its origin between vertebræ II. and III., and forms the large Brachial nerve, which supplies the muscles and skin of the arm. While in the trunk, it gives off a branch of considerable size, forming the *Coraco-clavicularis* nerve, which supplies the *Deltoideus*, *Sterno-radialis*, *Transverso-scapularis*, and *Obliquus abdominis internus* muscles. As stated above, a branch from II. sometimes joins III. or the coraco-clavicular. Very rarely I found the coraco-clavicular nerve originating from II., with only a small twig from III. Where II. fused with III. entirely, the coraco-clavicular is given off at the same place as II. passes away,

* Ecker: *loc. cit.*, p. 183.

† Ecker: *loc. cit.*, p. 183, also Adolphi, *loc. cit.*, 1893, p. 316.

‡ Ecker: *loc. cit.*, p. 187.

and there may be a branch of communciation between II. and the coraco-clavicular after they have left III. Generally also, a branch passes between III. and IV., most frequently running from III. to IV. Sometimes also IV. is found fused with III. at one point, or rarely, for some distance. Beyond its connection with II. or IV., where such exists, the brachial nerve sends from its posterior side a large branch to the *Latissimus dorsi* muscle, with a twig to the *Infraspinatus* muscle. Then a nerve passes off supplying the skin of the axilla and dorsal surface of the upper arm. A short distance further a large branch runs off to the pectoral muscles, while on its anterior face, the brachial nerve sends off branches to the *Deltoideus* muscle. Just beyond the origin of these nerves, and as the brachial enters the arm, or sometimes somewhat before, it divides, forming the *radialis* and *ulnaris* nerves.

The branches supplied by these two nerves are as follows:— The ulnar nerve passes along the upper arm, merely giving off one or two small branches to the skin of the inner surface. Just above the elbow it gives off a large branch, the *Cutaneus antibrachii inferior* (*dorsalis*), which supplies chiefly the skin of the dorsal surface of the hand. The *Ulnaris* continues its course into the forearm and there gives off the *Cutaneus antibrachii superior* nerve, passing to the skin of the inner side of the forearm. Much lower down, the *Ulnaris* divides into two—the smaller branch—*Ulnaris medialis*—supplies some of the flexor muscles and digit V.: while the larger—*Ulnaris lateralis*—supplies the adjacent sides of the digits II., III., IV., and V.: sending also a branch to the flexor muscles of the palm.

The radial nerve soon after its origin from the brachial gives off twigs to the *Deltoideus* and *Subscapular* muscles. Immediately below this is the *Ramus cutaneus superior* which supplies the skin of the outer surface of the upper arm. Three twigs are then given off to the Triceps muscle, two of these being close to the *Ramus cutaneus superior*, the other arising much lower. When it reaches the forearm the Radial nerve divides into the *Ramus radialis medialis*—which supplies some of the extensor muscles of the hand, the skin, and ends in digit V.—and the *Ramus radialis lateralis* which supplies other of the extensor muscles—and also by bifurcating branches, adjacent sides of the digits II., III., IV. and V.

Nerve IV. passes outwards from its foramen between vertebræ III. and IV., and runs near, and almost parallel to III., with which, as before mentioned, it has a communicating branch, or with which it may sometimes fuse for a longer or shorter distance. IV. is a thin nerve, never even approximating III. in size, as contrasted with *Bufo variabilis* in which IV. is stated by Adolphi* to be sometimes the thickest in the body. It gives off branches to the *Transversa-scapularis major*, very rarely one to the coraco-clavicular, and always, a branch which runs through the *Obliquus abdominis internus* to the *Rectus abdominis* muscle where it branches, and finally ends in the skin, being known as the *Thoracicus inferior* nerve.

Nerves V. to VII. are thin. They pass out obliquely backwards and outwards, and then downwards, on the ventral surface of the *Intertransversarius* muscle, and piercing the *Obliquus internus* divide forming the *Ramus muscularis*, and *Ramus cutaneus abdominalis*, supplying therefore the muscles and skin of the body wall. I have seen no trace of communication between V. and the brachial plexus, such as Adolphi has observed in *Pelobates fuscus*.† But in one case, there was on both sides of the body a well-defined branch passing from VII. to join VIII. above the origin of the ileo-hypogastric nerve.

Nerves VIII. to XI. form the sacral plexus. They pass out from the vertebral column and run backwards parallel with the urostyle into the pelvis, giving rise to the ileo-hypogastric, crural, and sciatic nerves, besides branches to the alimentary canal, oviduct and bladder. Nerve VIII. is generally somewhat thin, and in the great majority of cases forms the *Ileo-hypogastricus* nerve without any assistance from IX., though in a few instances fibres of IX. enter VIII. above the origin of the ileo-hpyogastric, and in one case, two ileo-hypogastrics were present, one composed of VIII. fibres only, the other of IX. fibres only, both having the same destination. In each case where IX. enters into the composition of the ileo-hypogastric, VIII. is somewhat thinner than usual, but VIII. is also thinner when IX. has no connection whatever with the ileo-hypogastric. This nerve divides as in Rana into two branches, the *Ramus*

* Morph. Jahr. xxii., 1895, p. 451. † *Loc. cit.* xxii., 1895, p. 451.

cutaneus abdominalis, which pierces the *Obliquus internus* muscle on its way to the skin, and the *Ramus muscularis*, supplying the abdominal muscles. The rest of the VIII. fibres pass backward to join the sacral plexus. Nerves IX. and X. are thick, IX. being generally the thicker of the two. The crural nerve generally consists of fibres from VIII. and IX. in almost equal proportions, and may contain fibres from X. or not, according as X. joins IX. above or below the origin of the *Cruralis*. Occasionally the crural nerve may consist chiefly of IX. fibres with a very small branch from VIII., or more seldom of chiefly VIII. fibres with very few from IX. Very rarely, the crural nerve may be composed of IX. fibres only, the whole of VIII. then forming the ileo-hypogastric, or more often, the *cruralis* consists of VIII. fibres only, in which case VIII. sends down also a branch to enter the sciatic nerve. As in Rana, the crural nerve runs out to the thigh and there lies upon the *Ilio-psoas* muscle in an angle between the *Adductor magnus*, and the *Rectus femoris anticus*. By far its larger branch, the *Ramus cutaneus femoris* supplies the skin while other branches supply the *Adductores longus* and *brevis*, *Ilio-psoas*, *Vastus internus*, and sometimes the *Rectus femoris anticus* and *pectineus*. From the fusion of IX. and X. arises the sciatic nerve, which supplies all those parts of the leg to which the *cruralis* does not send branches. It may or may not contain any fibres from VIII. according to the manner in which VIII. is connected with the sacral plexus, *i.e.*, whether it joins IX. above the origin of the crural from IX., or joins the crural itself.

The sciatic nerve most frequently consists of almost equal quantities of IX. and X alone, though often VIII. fibres enters into its composition and rather less frequently XI. fibres, while very rarely indeed X. forms the bulk of the sciatic, which then also contains very few IX. fibres; or it may be chiefly IX., in which case X. is a thin nerve, and VIII. fibres are always present. The sciatic nerve runs backwards and enters the thigh having almost the same relations as in *Rana*. While still in the body it gives off a branch—*Ramus cutaneus femoris posterior*—which supplies the skin of the ventral and inner sides of the thigh; and also sends a twig to the *Rectus internus minor*. In its course down the thigh, the sciatic gives off several branches

to the *Semimembranosus*, to both heads of the *Semitendinosus*, and to its posterior portion, to the inner surface and body of the *Adductor magnus*, to the *Biceps*, and to the *Rectus internus major*. Beneath the *Biceps* the sciatic divides, forming the *Tibialis* and *Peroneus*. The former passes down the leg to the foot, giving off nerves supplying the skin, the *Gastrocnemius*, the *Tibialis posticus*, the flexors of the fingers, the *Abductor hallucis*, and lower down divides into two nerves, the one supplying the ventral surface of the digits, and the other the deep or under-surface of the muscles of the sole. The second division of the sciatic, the peroneal, gives off immediately after its origin, nerves to the skin. It then divides into two—one half lies between the surrounding muscles and gives off branches to the *Tibialis anticus*, *Peroneus*, and *Flexores tarsi anterior* and *posterior*. The other half runs straight through the substance of the *Extensor cruris brevis*, to which it gives off a small branch, and continues down to the ankle, where it joins the other half, close to the bone, and below the *Flexor tarsi posterior*. Just before it unites, however, a branch is given off running to the skin and extensors of digits IV. and V., while the large nerve, formed by the junction, runs down to supply the extensors of digits I., II. and III., and the skin of the toes. This peculiar branching and junction of the peroneal nerve would appear to be the same as that described by Ecker for *Rana**—where the *Peroneus medialis* joins the *Peroneus lateralis*, forming a common stem, the *peroneus communis inferior*.

The XIth. nerve is a thin nerve, and may have a direct or an indirect connection with the sacral plexus. In the former case, in which XI. always take some part in the formation of the sciatic nerve, the whole nerve may enter X., or it may join X. by two or more of its own branches, either passing entirely into X. in this way, or sending down a branch which has an indirect communication with X. This latter means of connection is by far the most frequent, and is seen in instances where branches of XI. join branches of X. or of the sciatic, often forming a network.

Nerve XII., which Adolphi mentions as occurring in one per cent. cases in *Bufo variabilis*, and very rarely in *Pelobates fuscus*,

* Ecker: *loc. cit.*, p. 196.

I have found present in 3·2 per cent. cases in *Hyla aurea*, in each of which it either joins XI. directly or joins the network formed by the branches of X. and XI. This plexus supplies branches to the *Coccygeus* and *Levator ani* muscles, and to the bladder, cloaca, and oviduct; while, in addition, the last three seem sometimes to have nerve fibres from XI. only.

The thickness of a nerve is an essential element in deciding which is its more primitive, and which its more advanced, condition. I have therefore drawn up a series of tables comparable to those made by Adolphi for *Bufo variabilis* and *Pelobates fuscus*.

As a basis for the valuation, I have taken (1) the most frequently occurring thickness of nerve VI., the central nerve of those three which do not send any fibres to the limbs, as thickness 4. As in *Bufo variabilis*, nerves V., VI., and VII. have generally very nearly the same thickness, and as a rule in animals of approximately equal size, these three nerves have also about the same thicknesses. VII. is generally the same thickness as V. and VI. sometimes slightly thicker or thinner. In the one case in which I found any connection between it and the sacral plexus, VII. had one of the smaller thicknesses noted for that nerve. (2) The most frequently occurring thickness of nerve IX., in the sacral plexus, is represented as thickness 9. The figures 0 to 19 show, of course, only the relative thickness of the nerves, though in such a manner that for each increase in the absolute thickness of ·1 millimetre, there is an increase of 1 in the relative thickness; *e.g.*, thickness 4 corresponds to ·3 millimetres, thickness 5 to ·4 millimetres and so on.

So that this may be clearer I have drawn a curve showing the exact value of the separate thicknesses 0 to 19. Along the horizontal line are placed the numbers of the relative thicknesses consecutively, while the vertical represents the actual value of those separate thicknesses, increased some twenty times.

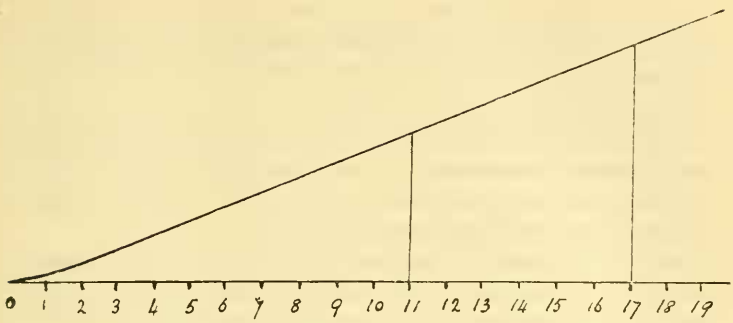

Fig. A

So far as I am able to judge from the data given by Adolphi, the numbers thus arrived at should be quite comparable with his.

I have examined 125 specimens of *Hyla aurea*, and instead of regarding, as Adolphi has done, each specimen as yielding two separate observations, one for each side, I have considered it as one observation, or where the two sides differ from one another as two half observations. This does not interfere with the comparison of the two sets of tables, as the percentage relations are not affected thereby. The following results are brought together in Table A.*

Nerve XII., as I have mentioned above, was found in 3·2 per cent. of all cases—of these 2·4 per cent. had thickness 1, and ·8 per cent. thickness 2.

Nerve XI. varies in thickness from 1 to 6—The majority of cases, 88·8 per cent. were divided between thicknesses 2 and 3, the former having 46·4 per cent., the latter 42·4 per cent. Thickness 4 and over occur but seldom. This nerve was present in every case, as constrasted with *Bufo variabilis*.†

In Nerve X. we find a wide range of thickness, viz., from 3 to 12. The majority, 82·4 per cent. are found among thicknesses 7 to 10. Thicknesses 4 to 6 are seldom seen, and 3, 11, and 12 very seldom.

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* All Tables referred to are placed at the end of the memoir.

† *Loc. cit.*, 1893, p. 321.

Nerve IX. has thicknesses 6 to 11 and 16, the latter, however, occurring only in one out of the 125 cases. 85·6 per cent. of all cases have thickness 8 to 10, the greater number of these having thickness 9.

Nerve VIII. Thicknesses 3 to 8 are present: 3 to 5 being most frequent, occurring in 88 per cent. of all cases—of these 39·2 per cent. have thickness 4. Thicknesses 6, 7, 8, occur in 6, 4, and 2 per cent. of cases respectively.

Nerve VII. varies in thickness from 2 to 5. Thicknesses 2 and 5 are seldom met with—while thickness 3 occurs in 27·2 per cent., and thickness 4 in 65·6 per cent. of all cases, these two thicknesses having thus a total of 92·8 per cent.

Nerve VI. Thicknesses 3 to 6 occur, 5 and 6, however, but rarely—thickness 3 was found in 36 per cent., and thickness 4 in 59·2 per cent. of all cases—total for thicknesses 3 and 4 being thus 95·2 per cent.

Nerve V. varies from 1 to 5 in thickness: 91·2 per cent. of the cases having thickness 3 or 4, while thicknesses 1 and 2 occur very seldom.

Nerve IV. We find here thicknesses 2 to 6 of which 2 and 6 are each only met with in ·8 per cent. of cases. Thicknesses 3 and 4 are equally frequent, each occurring in 44 per cent. of all cases, while in 10·4 per cent. of cases we find thickness 5.

Nerve III. has a considerably greater thickness than IV., the smallest thickness seen here being 7, and that only in one instance (·8 per cent.)

On the other hand, the greatest thickness seen was 19, this also occurring in only one instance (·8 per cent.). Of the intermediate thicknesses, I observed from 9 to 15 only, of which 80·8 per cent. cases were distributed between thicknesses 11, 12 and 13; 12, the most frequent, being found in 40 per cent. of all cases.

Nerve II. varies in thickness from 3 to 6. By far the greatest number of instances 79·2 per cent., or about three-fourths, have thickness 4, while thickness 5 occurs in 12 per cent. of cases; thicknesses 3 and 6 are not often found in connection with nerve II.

In comparing Table A with the corresponding Table for *Bufo variabilis*,* the following are the principal differences noticeable:—

* Adolphi, *loc. cit.*, p. 321.

While in *Bufo variabilis*, nerve XII. only occurs in one per cent. of all cases, in *Hyla aurea*, it was noted in 3·2 per cent. Nerve XI., which was found to be absent in 4·5 per cent. cases in *Bufo variabilis*, was never absent in *Hyla aurea*, and while in the latter, the smallest thickness (1) is very rare (1·6 per cent.), the next thickness being the most common, in *Bufo variabilis* the smallest is the most frequent (36·5 per cent.).

In *Hyla aurea*, nerve X. has a much wider range of thickness than in *Bufo variabilis*, and while in the latter the greatest number of cases, have the greatest thickness noted for that nerve (9), in *Hyla aurea* we find that the greatest number of cases have thickness 8, which is in the centre of the range for that nerve (3 to 12), the number of cases in which other thicknesses are found gradually increasing up to 27·2 per cent. cases for thickness 8, and then gradually decreasing again. A similar difference is seen when we compare the percentages for nerve IX. In *Bufo variabilis* we again find the greatest thickness 9, in the greatest number of cases (54 per cent.), the percentage occurrence increasing with the increasing thickness up to that point, while in *Hyla aurea* we see that the percentage increases with an increase in thickness up to 9 in the centre of the range for this nerve, and then diminishes with a further increase in thickness. In nerve VIII. there is no marked difference. In *Bufo variabilis* 97·9 per cent. of the cases are divided between the three least thicknesses (4 to 6), and in *Hyla aurea* 88 per cent. are distributed between the three least thicknesses, which, in this case, are 3 to 5. For nerves VII., VI. and V. in *Bufo variabilis* we have no data for comparison, but in *Hyla aurea* we find that for each nerve thicknesses 3 and 4 have by far the greatest number of cases, 4 always preponderating in this respect over 3.

Nerve IV. in *Hyla aurea* has a much more restricted range than in *Bufo variabilis*, and while in this form, two-thirds of the cases have the smallest thickness (4), in *Hyla aurea* thicknesses 3 and 4 are found in a total of 88 per cent. of all cases, the smallest thickness (2) being very rare (·8 per cent.).

Nerve III. The differences between the percentages for this nerve in the two species recall those noted in the case of nerves X. and IX. While in *Bufo variabilis* the greatest number of

cases (95 per cent.) have the greatest thickness (12), in *Hyla aurea* we find that the central thickness (12) of the range has the greatest number of instances (40 per cent.), with a gradual increase in percentage up to this, and then a gradual decrease.

It will be noticed that both nerves IX. and III. in *Hyla aurea* reach a greater thickness than any other nerve in one case in each nerve, and also that the 3 or 4 thicknesses below these extremes are not met with.

Nerve II. In both *Bufo variabilis* and *Hyla aurea* the great majority of instances have the smallest thickness but one, being in the former, thickness 5, in the latter, thickness 4.

It has been found from observations on the larvæ of several of the Anura,‡ that in the tail of the larva are several pairs of spinal nerves which disappear during metamorphosis. Between this and the adult, intervene stages in which nerves X., XI. and XII., have in succession the following thicknesses 9, 4, 1; 8, 2, 0; 7, 1, 0, and sometimes 6, 0, 0. But since we must regard the larval condition as similar to that of the ancestors of that animal, the first of the above four stages is the most primitive, and the last the most highly advanced. From this reduction of the most posterior spinal nerves in order, we can deduce the most primitive and the most advanced condition of spinal nerves anterior to these. For this purpose it is necessary to proceed from these most posterior nerves to those in front of them.

The following Tables, B, 1 to 28, show all the combinations of thicknesses found in those specimens of *Hyla aurea* examined.

Tables B, 1 to 8 show the various thicknesses with which nerve XII. occurs, but owing to the few specimens containing examples of this nerve we cannot rely too much on results obtained from them, unless as confirming other results.

1. While XII. decreases, XI. increases. Thickness 1 of nerve XII. is found with the higher thicknesses 3 and 5 of nerve XI., while thickness 2 of XII. is only found with thickness 2 of nerve XI.

2. While XII. decreases, X. increases. Nerve XII., thickness 1, is only found with the higher thicknesses 6, 7, 8, 9, of nerve X.; and nerve XII., thickness 2, with nerve X., thickness 5.

‡ Adolphi: *loc. cit.*, 1893, p. 335.

3. While XII. decreases, IX. increases. Nerve XII., thickness 2, is only found with nerve IX., thickness 9, while nerve XII., thickness 1, is also found with nerve IX., thickness 11.

4. While XII. decreases, VIII. decreases also. Nerve XII., thickness 2, is found only with nerve VIII., thickness 5, while nerve XII., thickness 1, is found also with nerve VIII., thickness 3.

5. While XII. decreases, IV. increases. Nerve XII., thickness 2 is only found with nerve IV., thickness 3; while nerve XII., thickness 1 is also found with nerve IV., thickness 4.

6. While XII. decreases, III. decreases also. Nerve XII. only occurs with the central thicknesses of the series for nerve III.: but these appear to show that nerve III. decreases with nerve XII. Thus: Nerve XII., thickness 2 is only found with III., thickness 12, while thickness 1 of nerve XII. is also found with nerve III., thicknesses 10 and 11.

7. This table shows no regularity whatever.

8. While XI. diminishes, so does X. In the higher thicknesses of nerve X., there are some irregularities, but from thickness 10 downwards, nerve XI. seems to decrease in thickness as nerve X. also diminishes. The frequency of nerve X., thickness 10, diminishes almost regularly with the decreasing thickness of nerve XI., and was never noted in combination with thickness 1 of nerve XI. The frequency of nerve X., thickness 9, decreases with a falling thickness of nerve XI., reaching a minimum with nerve XI., thickness 2. The frequency of nerve X., thickness 8, increases and then decreases with decreasing thickness of nerve XI., and in the smaller thicknesses of nerve X., the frequency increases with a diminishing thickness of nerve XI., as would be expected.

9. This table shows a somewhat irregular combination. While nerve IX. increases, nerve XI. first increases and then diminishes. The frequency of nerve IX., thickness 7, increases with increasing thickness of nerve XI., while nerve IX., thickness 8, and nerve IX., thickness 9, are very irregular.

10. If we overlook irregularities in the smallest and higher thicknesses of nerve VIII., we find that as nerve XI. diminishes, nerve VIII. increases. The frequency of nerve VIII., thicknesses 3 and 4 varies greatly. That of nerve VIII., thickness

5, increases as nerve XI. decreases, also nerve VIII., thicknesses 6 and 7.

11. Nerve XI. and IV. show only a slight relation to one another. As nerve XI. decreases in thickness, the frequency of thickness 3 of nerve IV. increases, reaching its maximum with nerve XI., thickness 2. Independently of irregularities in nerve XI., thickness 1, due probably to the small number of observations here, we find that the frequency of thicknesses 4 and 5 of nerve IV. tend to decrease with decreasing thickness of nerve XI., so that it would appear that nerve IV. decreases with a decreasing thickness of nerve XI.

12. Nerves XI. and III. vary very irregularly, the percentages showing no constant progression. The table shows that the highest thickness 19 of nerve III. is found with a lower thickness (2) of nerve XI., than is the lowest thickness (7) of nerve 3. This may be taken to indicate the fact that while nerve XI. decreases nerve III. increases, but since there are but few observations for those particular thicknesses, it is doubtful how much reliance can be placed on this.

13. The only definite relations shown by this table to exist between nerves XI. and II. is the fact that the smallest thickness (3) of II. only exists with the three smallest thicknesses of nerve XI. The converse is not, however, by any means true. Further, the frequency of the occurrence of intermediate thicknesses gives no information whatever on the variations of nerves XI. and II. The highest thickness, however, 6, of nerve II., does not occur with the two lowest thicknesses of nerve XI. Therefore, probably while nerve XI. diminishes, nerve II. diminishes also.

14. As X. decreases, IX. tends to increase. The two smallest thicknesses of nerve X. are only found with the four highest thicknesses of nerve IX., and rather more frequently with the two highest, 11 and 16, of nerve IX.

15. While X. decreases, VIII. increases. The percentage relations are somewhat irregular; but it will be seen that nerve VIII., thickness 4, reaches a maximum with nerve X., thickness 9; and nerve VIII., thickness 5, with nerve X., thickness 5 (omitting thicknesses 3, 11, and 12, of nerve X., in which there is but a single occurrence), while nerve VIII., thickness 6, has its maximum with nerve X., thickness 4; also nerve VIII., thicknesses 7 and 8, occur chiefly with a lower thickness of

nerve X. (6), than does nerve VIII., thickness 3. We may thus say that there is a tendency for VIII. to increase in thickness as X. decreases.

16. As X. diminishes, IV. may diminish also. Again we find great irregularities. The maximum frequency of nerve IV., thickness 4, independently of single occurrences, is found with thickness 9, of nerve X., while that of nerve IV., thickness 3, is found with nerve X., thickness 7. On the other hand nerve IV., thickness 2 occurs only with nerve X., thickness 9, and nerve IV., thickness 6, only with nerve X., thickness 8.

17. If we examine first the smaller thicknesses 10 to 12, of nerve III., we find a tendency for nerve III. to decrease in thickness with a decreasing thickness of X. But thicknesses 13 and 14, of nerve III., appear to directly oppose this, since their maxima of frequency occur with the lower thicknesses of nerve X. On the other hand, however, the table as a whole (exclusive of thickness 19, of nerve III.), would appear to show a decrease in nerve III. with a decrease in nerve X.

18. As X. decreases, II. decreases also. The frequency of thicknesses 3 and 4, of nerve II., seem to point to a decreasing thickness of nerve II., corresponding to a falling thickness of nerve X.

19. While IX. increases, VIII. increases also. The relations between these two nerves are very indefinite, but there is evidently a tendency for an increase in thickness of nerve VIII. to accompany an increasing thickness of nerve IX., as seen in the position of the maxima of frequency of thicknesses 4, 5, and 6 of nerve VIII., with thicknesses 7, 10, and 10 of nerve IX.

20. While IX. increases, IV. increases also. The frequency of nerve IV., thickness 3, reaches a maximum with nerve IX., thickness 7; nerve IV., thickness 4, with nerve IX., thickness 9; and nerve IV., thickness 5, with nerve IX., thickness 11; while nerve IV., thickness 2, is found with nerve IX., thickness 8, and nerve IV., thickness 6, with nerve IX., thickness 11.

21. While IX. increases, III. increases also. The lowest thicknesses, 7 and 9, and highest, 14 to 19, of nerve III., bear evidence rather in favour of this statement, while the frequency of the intermediate thicknesses of nerve III., *i.e.*, 10, 11, 12 and 13, reach their maxima with nerve IX., thicknesses 7, 9, 10 and 11 respectively.

22. Nerves IX. and II. show no decided relations with one another. The frequency of nerve II., thickness 3, 4 and 5, reaches its maxima with nerve IX., thicknesses 10, 7 and 11 in order. This might be understood to indicate increase in the two nerves. On the other hand nerve II., thickness 3, occurs chiefly with nerve IX., thickness 10, and nerve II., thickness 6, with nerve IX., thickness 9.

23. While VIII. increases, IV. increases also. Nerve IV., thickness 2, only occurs with nerve VIII., thickness 3, and nerve IV., thickness 6, only with nerve VIII., thickness 8; also the maxima of frequency of nerve IV., thicknesses 3, 4 and 5, are found with nerve VIII., thickness 6, 7 and 8 respectively.

24. Nerves VIII. and III. probably increase concurrently, though the table appears somewhat irregular. The two smallest thicknesses 7 and 9 of nerve III. are only found with the two smallest thicknesses 3 and 4 of nerve VIII. The maxima of frequency of nerve III., thicknesses 10, 11, 12, 13 and 14, are found severally with nerve VIII., thicknesses 3, 6, 5, 8 and 8.

25. No definite relations appear between nerves VIII. and II. in this table beyond the occurrence of the highest thickness (6) of nerve II. with nerve VIII., thicknesses 3 and 4 only, which may be understood to signify that an increase in VIII., is accompanied by a decrease in II.

26. While IV. decreases, III. decreases, or while IV. increases, III. increases. Independently of slight irregularities in nerve III., thickness 10, we find that there is a gradual increase in thickness of nerve III., corresponding to an increase of nerve IV. This is confirmed by the occurrence of nerve III., thicknesses 15 and 19 with thicknesses 4 and 5 of nerve IV., while nerve III., thicknesses 7 and 9 occur with nerve IV., thicknesses 3 and 4.

27. Nerves IV. and II. appear to have no regular relation between them beyond the fact that nerve II., thickness 3, occurs slightly more frequently with nerve IV., thickness 5, while nerve II., thickness 6, only occurs with nerve IV., thicknesses 3 and 4.

28. This table distinctly shows on the whole an increase in thickness of nerve II., with an increase in thickness of nerve III. Thus nerve II., thicknesses 3, 4, and 5 occur chiefly with nerve III., thicknesses 9, 10, and 13. Further, nerve II.,

thickness 3, occurs chiefly with nerve III., thickness 9, and nerve II., thickness 6, with nerve III., thickness 10.

Comparing the evidence of these tables with that obtained by Adolphi for *Bufo variabilis*, we find that on the whole there is a confirmation of Adolphi's results with reference to the sacral plexus. In Table 9, showing the variations in thickness of nerve XI. accompanying those of nerve IX., there is partly a confirmation and partly a denial, similarly in Table 17 for nerves X. and III. Tables 13 (nerves XI. and II.) and 18 (nerves X. and II.), on the other hand give a somewhat positive result, where in *Bufo variabilis* we see no connection: while Tables 20 (nerves IX. and IV.), 23 (nerves VIII. and IV.), 25 (nerves VIII. and II.) perhaps, 26 (nerves IV. and III.), and possibly 27 (nerves IV. and II.), offer results directly opposed to those obtained from similar tables for *Bufo variabilis:* while Table 28 (nerves III. and II.) exactly compares with Adolphi's results for similar nerves. The chief difficulties are with reference to the brachial plexus. Instead of nerve IV., the most posterior of the brachial plexus in *Hyla aurea*, being in a condition of decrease in thickness as in *Bufo variabilis*, Tables 20 and 23 distinctly show that it is in a condition of increase, Table 11 being the only one disagreeing with this in the slighest degree. Moreover, if this inference be correct, viz., that nerve IV. is in a state of increase in thickness, then by Table 26, nerve III. also must be increasing in thickness, and this result for nerve III. exactly agrees with Adolphi's observations for *Bufo variabilis*. Further, Tables 13, 18, 25, and 27, in which a relation is seen between nerve II. and the other nerves, point to the fact that nerve II. is decreasing in thickness, and this also agrees with *Bufo variabilis*.‡ Assuming that Adolphi's conclusions based on his examination of the larvæ of *Rana temporaria* and *Pelobates fuscus* be correct, that the thicker condition of nerves X., XI., and XII. is the more primitive, if as seems to be the case from the tables in *Bufo variabilis*, a greater thickness of nerve IV. is found with a greater thickness of nerves XI. and X. and *pari passu* with these, the smaller thicknesses of nerves IX., VIII., and III., and *vice versâ*, the smaller thicknesses of nerves XI., X. and

‡ Adolphi: *loc. cit*, 1893, p. 341.

IV. accompany the greater thicknesses of nerves IX., VIII., and III.; it is not easy at first sight to understand why in *Hyla aurea* while the sacral plexus agrees entirely with that of *Bufo variabilis*, the brachial plexus should show such a marked unconformity with the European forms. The true bearing of this difference in nerve IV., will, however, appear later on in this paper.

Of the other spinal nerves, V., VI., and VII., have a fairly constant and similar thickness, viz., chiefly 3, 4 and 5, the greatest percentage in each having a thickness of 4.

In order to trace the influence of this change in the thickness of the spinal nerves, on their form and position, I have summed up my observations on the relative positions of the nerves forming the two plexuses in a series of figures and tables. Fig. 1 to 4, and Tables C to L relating to the sacral plexus, and Fig. 5 and 6, and Tables M to O to the brachial plexus.

Fig. 1 and Table C show the gradual development by means of which the function of nerve IX. in giving rise to the ileo-hypogastric nerve has been passed on to nerve VIII.

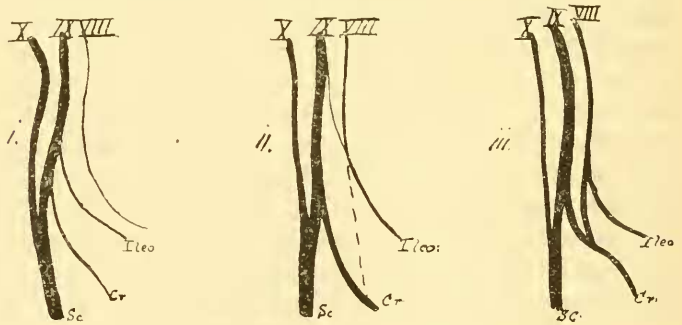

Fig. 1.

Looking at Table C and remembering the results which we obtained from the previous set of tables, that the smaller thicknesses of nerve VIII. are the more primitive, and the highest the most advanced—we see that without any question form iii. is the most advanced, for it not only is the sole one occurring with all the thicknesses from the lowest to the highest, but it gradually increases in frequency with an increasing thickness of nerve VIII., until with thicknesses 5 to 8 it reaches 100 per

cent., being the only form having those thicknesses of nerve VIII. On comparing this with Fig. 1, form iii. (to which the Table C, iii. refers), we find that the ileo-hypogastric originates entirely from nerve VIII., the remainder of which passes down and unites with a branch from IX. to form the *cruralis*, that is to say, the region supplied by the ileo-hypogastric, is controlled by nerve VIII. only. On the other hand the most primitive form, according to the percentages, should be form i., which only occurs with the smallest thickness of nerve VIII. Fig. 1, form i., shows that in this the most primitive condition, nerve VIII. takes absolutely no share in the formation of the ileo-hypogastric nerve, this as well as the *cruralis* being supplied by nerve IX. only. Between these two forms, i., the most primitive, and iii., the most advanced, we have as an intermediate stage form ii., in which we find VIII. and IX. taking an equal share in forming the ileo-hypogastric. The *cruralis* is variously formed when this is the case, four per cent. of such cases having the position and relations shown by the continuous lines only, and sixty per cent. that shown by both continuous and dotted lines. I have not separated these two forms in the table, as there are but very few observations, and also I shall discuss the progression of the crural nerve in detail later on.

It will thus be seen that whereas the ileo-hypogastric in its more primitive condition originates from nerve IX., as it advances, it tends more and more to become connected with nerve VIII., until in the great majority of the present forms it is only connected with that nerve, thus showing a transference of function forwards, *i.e.*, from IX. to VIII.

A further instance of this was noted in one specimen in which the ileo-hypogastric branch of VIII. received a branch—fine, certainly—from VII. It would thus appear that there is now a tendency for VII. to be drawn into the sacral plexus, and possibly it will, later on, take part in the formation of the crural nerve also, progressing in just the same way as VIII. has done, as may be seen from Figs. 1, 2 and 3. Of this, however, one can only speak with reserve, inasmuch as it only occurred in one specimen, and then not in conjunction with any of the greater thicknesses of VII. or VIII. (VII. having thickness 3, and VIII. thickness 5). Table C shows that by far the most

common form at present is form iii.; this, however, is not frequent with the higher thicknesses, 6, 7 and 8, so that in an isolated case of the more advanced form, one can understand that it might not occur with the greatest thickness, as a strict inference would imply.

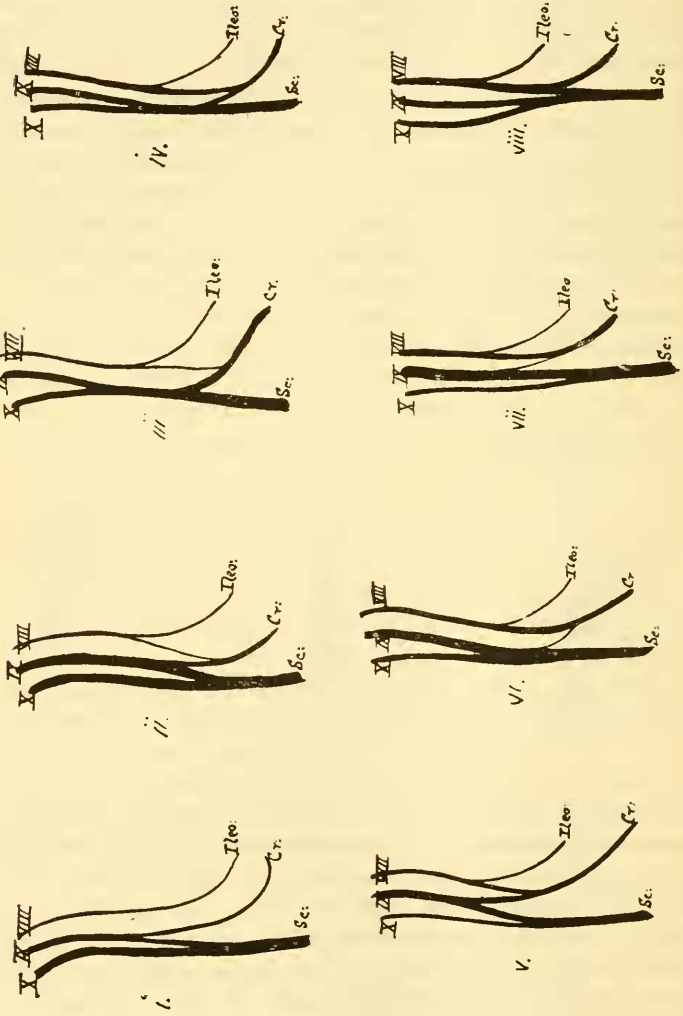

Fig. 2.

Table D and Fig. 2 show a steady progression in the manner in which the *cruralis* originates. Since nerve VIII. is in a condition of increasing thickness, we learn from Table D that the most advanced form is viii., this being the only form occurring with the highest thickness, 8, and also since its greatest frequency, even excluding that with thickness 8, is at least with as high a thickness (7) as that of any other form. Further, we learn from the same source, that form i. is the most primitive, its frequency reaching a maximum with the lowest thickness 3, and gradually decreasing up to thickness 5. Referring to Fig. 2, we see that these two extremes point to the same kind of advancement as took place in the ileo-hypogastric, in other words, we find that in form i., the most primitive, the *cruralis* consists of fibres from nerve IX. only, while in form viii., the most advanced, the fibres come from nerve VIII. only, a transference of function from IX. to VIII., continuing that of the ileo-hypogastric, which, being nearer the exit of the nerve from the spinal cord, seems to lead the way in this respect. Of the intermediate stages, it would seem from the table that ii. is the most primitive, and iii. the next, iv., v., vi. and vii. following in succession. Fig. 2 shows us the following characters for each of these several forms. In form ii., we see that the *cruralis* is formed of chiefly IX. fibres, with a small branch from VIII. In form iii., similar relations exist between the fibres from IX., and from VIII., with the addition of a certain number of fibres from X. The next advance is seen in the greater proportion in the *cruralis* of fibres from VIII., which equals that of the IX. fibres in both iv. and v., the *cruralis* in iv. showing fibres from X., which are absent in v. Up to this, forms i., ii., iii., iv., and v. have occurred from the lowest thickness of VIII. upwards. Form vi., however, does not occur with the lowest thickness 3, showing the next step upwards, while form vii. in the table shows another similar step in advance. In Fig. 2 these two forms vi. and vii. exhibit the same relationships to one another as were seen in the two previous pairs. Thus, in both, the *cruralis* consists chiefly of VIII., with only a small branch from IX., fibres from X. entering into its composition in form vi., but not in form vii. Bearing in mind the general transferrence in the origin of the *cruralis* from IX., and probably previously from X., though of

this we have only indirect evidence, to VIII., we notice in Fig. 3 a gradual but certain advance in this direction.

A somewhat peculiar exception to this is seen in forms ii. and iii. in the figure, which would seem to reverse the natural order, but in the face of the evidence given for those two forms in the table, form iii., certainly occurring with a higher thickness than ii., I have not felt justified in changing the order, though it would certainly appear that a form in which the *cruralis* contains X. fibres, as well as IX. and VIII., would be more primitive than one in which only IX. and VIII. fibres occur. This deviation, however, is not nearly sufficient to nullify the evidence of the rest of the table, which entirely agrees with Adolphi's results for *Bufo variabilis*, viz., that "nerve VIII. originally destined for the body wall (by the ileo-hypogastric) is passed over to take care of the leg (by the *cruralis*), and gradually gains an ever-increasing value in that direction."

I have also drawn up a Table (E), which should show the relations between the thickness of nerve IX. and the form of the *cruralis*, if any exist. There is a somewhat regular progression in forms i. to v., but forms vi., vii., and viii., are very irregular: also

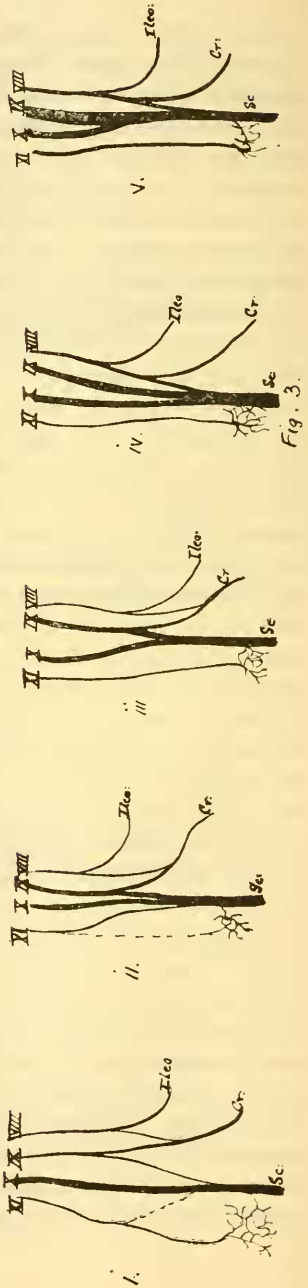

Fig. 3.

we see that the three most primitive forms i., ii., iii., occur with lower thicknesses than the most advanced (viii.).

Tables F, G, H and K, were compiled for the purpose of ascertaining whether the variations in the composition of the sciatic nerve, bear any relation to the variation in thickness of any component nerve.

I find that with the thickness of VIII. (Table F), the only relations noticeable are that form i., which is evidently the most primitive from its occurrence only with two of the smaller thicknesses of nerve VIII., occurs most frequently with a smaller thickness than does form v., which must be the most advanced, since it does not occur with the two smallest thicknesses of VIII. In the three intermediate forms there is a distinct increase in the thickness with which each of the three forms occur most frequently, *i.e.*, form ii. is found most often with thickness 3, form iii. with thickness 4, and form iv. with thickness 7. Thus, although the table as a whole appears somewhat irregular, these two parts would seem to show a distinct advancement *pari passu* with an increase in thickness. The absence of a strict progression is scarcely to be wondered at, since VIII. really only takes any share in the formation of the sciatic in two out of the five forms. This will be clear on reference to Fig. 4.

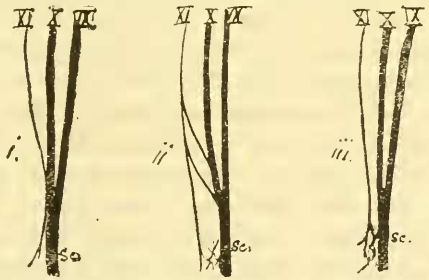

Fig. 4.

In this it will be seen that the progression found in Table F, when compared with the five figures of the forms of that table, offers a confirmation of the forward transference of function found in connection with the *cruralis* and ileo-hypogastric nerves.

In form i. (Fig. 3), we see the sciatic composed chiefly of X. fibres assisted by some from IX., having none from VIII. In forms ii., iii., and iv., X. and IX. enter almost equally into the composition of the sciatic nerve, in form ii. some fibres from XI. enter this union, in iii. we have only X. and IX., in iv. we have the first appearance of VIII. fibres in this nerve. Form v., the most advanced according to Table K, might have been allotted that position by inference from the advance of the four previous forms as seen in the figure, since in it we find the sciatic with a majority of IX. fibres, and also a constant presence of VIII. fibres, X. sinking to a third place in this respect. A further explanation of the irregularity in the maximum percentage frequency in Table K here suggests itself. Just as we find forms ii., iii., and iv., form a complete series in themselves in the table, so we find from the figures that this is also the case, all three coming under a general description, viz., possessing equal quantities of X. and IX. fibres, which forms an intermediate stage between form i. with a majority of X. fibres, and form v. with a majority of IX. fibres.

Table G does not appear to give us any evidence beyond the fact that form i., which we have found to be the most primitive, occurs with a lower thickness than form v., the most advanced. Table H on the other hand shows a well-marked order agreeing with that proved from Table F and Fig. 3. Since nerve X. was found to be in a state of decreasing thickness the most primitive composition of the sciatic ought to occur chiefly with the higher thicknesses, and the more advanced forms in a definite order with the decrease in thickness. Such is the case. Excluding the isolated cases in thickness 11 we find that form i. occurs most frequently with thickness 10, form ii. with thickness 11 and then thickness 9, form iii. with thickness 8, form iv. with thickness 6, and form v. with thickness 3.

Table K showing the relations between the thicknesses of XI. and the composition of the sciatic offers a further confirmation of those results, since we find that XI. being in a decreasing condition, form i. occurs most frequently with thickness 5, form ii. with thickness 5, form iii. with thickness 3, excluding an isolated case in thickness 1, form iv. with thicknesses 2 and 1, while form v. chiefly occurs with thickness 2.

We have yet to describe in connection with the sacral plexus, the further relations which a decreasing thickness of XI. bears to the advancement of the nerves in this region.

According to Table L, nerve XI. being in a state of decrease in thickness, we see that form i. is the most primitive, and form iii. the most advanced, form ii. being an intermediate stage.

Fig. 4 will show the bearing of this on the results of previous tables. In form i. we see the closest connection of XI. with the sciatic nerve, the whole of nerve XI. entering into the composition of the sciatic. In ii., we have nerve XI. entering the sciatic, or joining X. by two or more trunks, while in form iii., XI. has no share in the sciatic at all, merely joining branches of that nerve which supply only the viscera at the posterior end of the body with some of their muscles.

On comparing these results of observations on the sacral plexus of *Hyla aurea* with those made by Adolphi on *Bufo variabilis*, and *Pelobates fuscus*, it will be seen that there is a marked similarity with those results, viz., that the centre of gravity of the sacral plexus is gradually moving towards the head, or in other words, nerves VIII. and IX. increase in thickness as X. and XI. decrease in thickness, and *pari passu* with this change in size and consequent advancement, nerves VIII. and IX. are gradually losing their original relations to the body wall and are assuming a greater importance in the innervation of the leg. It would further appear from the tables relating to the most posterior spinal nerves of *Hyla aurea*, especially XI., that there is at the same time a change whereby these nerves are losing their connection with the leg, and are, and will supply, in its place, the viscera of the hinder part of the trunk, perhaps preparatory to dying out altogether, as XII. is now doing.

It remains to be seen what relations the thickness of the anterior nerves of the spinal column bears to their form.

Since we found in Tables B, 20 and 23, that IV. is increasing in thickness, then the most primitive form of that nerve will occur most frequently with the smaller thicknesses of the nerve. In Table M, therefore, form i. is the most primitive, and form iv. the most advanced, forms ii. and iii. being intermediate stages.

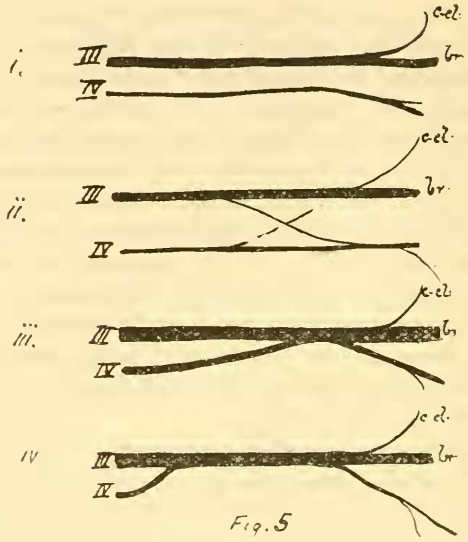

Fig. 5

Fig. 5 shows the following positions of the nerves in the forms i. to iv. In form i., nerve IV. is distinctly free from nerve III.; in form ii. a branch passes between the two nerves, either from nerve III. to IV., or *vice versâ;* in form iii. we find a still closer connection, III. fusing with IV. at one point, while in form iv. the fusion is continued for some distance. But since we found that nerve III. agreed in its manner of increase with that in *Bufo variabilis* and *Pelobates fuscus*, it will be most instructive to take its evidence into consideration.

In Table N then the most primitive form should occur most frequently with the smaller thickness and the most advanced with the higher thickness of nerve III., and according to this table we find that form i., which Table M shows to be the most primitive, occurs chiefly with a lower thickness than does form iv. the most advanced, which so far confirms the previous results. Form iii. shows a slight irregularity in thickness 15, which may possibly be due to the small number of observations in that thickness. It seems therefore that in *Hyla aurea*, as nerve IV. increases in thickness, advancing in development, it takes an increasing share in the formation of the brachial plexus.

With reference to the condition of nerve II. with regard to the brachial plexus, we find the following results :—

Since nerve III. is increasing in thickness, we must regard forms i., ii. and iii. as the most primitive, since they occur mostly or only with the lower thicknesses of III ; forms iv. and v. on the other hand occur not only with the four lower thicknesses of III., but also with the five higher ones. The percentages are somewhat irregular in their progression.

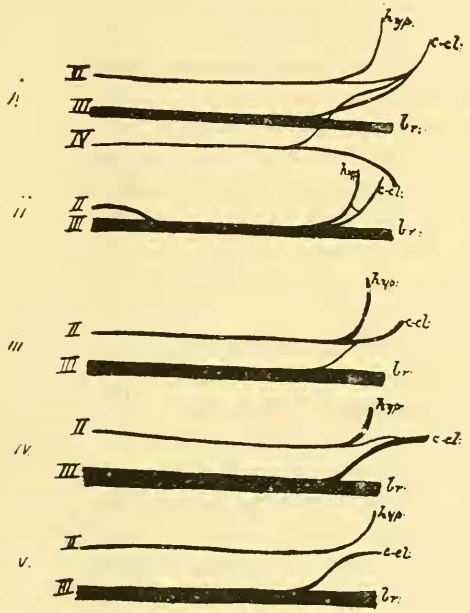

Fig. 6

Fig. 6 shows the positions of the nerves in these forms. In form i. we find a connection of the coraco-clavicular with nerves II. and IV., nerve II. thus taking a share in the brachial plexus. This condition, however, was only found on one side of one specimen and so might be regarded as an aberrant condition. In form ii. we see the closest connection of II. with the brachial plexus, this nerve being fused entirely or in part for some considerable distance with III. In form iii. the connection

is less marked, here the coraco-clavicular is composed chiefly of nerve II. having only a fine branch from III. A modification in the proportions of the fibres from the two nerves would readily give rise to form iv., in which the coraco-clavicular arises as a branch from III. with a few fibres from II. passing either to III. itself or to the coraco-clavicular. In form v., nerve II. has no connection whatever with the brachial plexus. This is what might have been predicted from the fact that IV. is taking an increasing share in the brachial plexus. But when we come to compare with this the Table (P) showing the thicknesses of nerve II. with which these forms are found we meet with a strange discrepancy.

If we regard nerve II. as being in a state of decrease as deduced from Tables 13, 18, 25, etc., we find that the order of the forms in Fig. 6, according to their point of development, beginning with the most primitive, should be v., iv., ii., iii.—excluding i. From this we obtain the remarkable result that as nerve II. *decreases* in size, it assumes fresh duties in addition to those which it had previously. Especially is this unexpected here, as since II., in a diminishing condition, takes upon itself to give rise to the coraco-clavicular, it is difficult to conceive from whence the region supplied by this branch is to derive its nervous supply, as II. diminishes to a thickness of 0. Further, if in the face of Tables B, 13, 18, 25 and 27, we accept the evidence of Table B, 28, viz., that II. increasing in thickness, we merely have the difficulty reversed, for an *increase* in thickness of a nerve is unnecessary for a more and more restricted area of action. I have considered that probably this irregularity is due to the change in habit of *Hyla aurea*, originally an arboreal form, to a terrestrial life. In this connection, it would be interesting to know whether the true Tree frogs of Europe show any deviation from the general combinations of *Bufo variabilis* and *Pelobates fuscus*. In the absence of a more extended knowledge on this point, we may accept for the present, at least, the evidence of Table O, since it seems most in accordance with all the facts relating to nerves IV., III. and II.

The increasing thickness on the part of nerves IV. and III. and the apparent decreasing thickness of nerve II. together with the above tables, indicate the fact that in the brachial plexus of

Hyla aurea we have a further stage of what Bateson calls backward Homœosis of the nerves composing this plexus, in other words that we have here, as in the sacral plexus "an assumption by one member of these Meristic series of the form and characters proper to other members of those series." But, whereas in the sacral plexus, nerves VII. (probably), VIII. and IX. are exercising in an increasing degree the functions previously exerted only by nerves *posterior* to them (viz., IX., X., XI. and XII.); in the brachial plexus, nerve IV. appears to take up new duties previously performed only by II. and III.

We have seen that in the Urodeles and in *Pipa* among the Anura there is a nerve anterior to II., viz., the sub-occipital, which passes out as the case may be between the skull and the first vertebra, or else pierces the first vertebra; also, we found that in *Hyla aurea* as in the Anura generally this is absent.

Pipa thus seems to be, in some degree, an intermediate form between the Urodeles and the other Anura. A further stage is seen in *Rana*, since "the fact that the last spinal nerves to join the brachial plexus in *Pipa* are the IIIrd, while in *Rana* they are IVth, is again an evidence of backward Homœosis."*

That in *Hyla* we have a continuation of the same process is, I think, beyond doubt, since we have an increasing thickness both in III. and IV., concurrent with a decreasing thickness in II., and also a most intimate connection of IV. with the brachial plexus. To sum up the results of these observations on *Hyla aurea*, in a few words, we have found a forward Homœosis in the sacral plexus, also a backward Homœosis in the brachial plexus. We may therefore conclude that in the Anura, as represented by the forms studied in this connection, there is an advancement in the direction of a concentration of the origin and functions of the spinal nerves towards the central region of the body.

APPENDIX.

In addition to *Hyla aurea*, I have examined a few other forms found in Australia, viz., *Helioporus pictus*, and *Limnodynastes*

* Bateson: Materials for the Study of Variation, p. 143.

tasmaniensis from Victoria, and *Limnodynastes ornatus* and *Chiroleptes platycephalus* from Central Australia, for specimens of which, together with those of *Hyla aurea*, I am indebted to Professor Spencer. There being but few observations in each case, I have not attempted to tabulate the results, as a few words with a reference to the figures and tables of *Hyla aurea* will make their size, condition, etc., clear, since here I have taken the same standards for comparison. The manner of distribution and position of the various nerves do not differ very greatly from those of *Hyla aurea.*

In *Helioporus pictus* the various thicknesses found are the following :—

Nerve.	Thickness.	Per cent.	Thickness.	Per cent.
II.	4	50	3	50
III.	5	50	6	50
IV.	6	50	3	50
V.	2	50	2	50
VI.	3	50	2	50
VII.	2	50	3	50
VIII.	3	50	2	50
IX.	7	50	5	50
X.	7	50	5	50
XI.	1	50	2	50

Nerve XII. was not found to occur at all.

The following conditions were observed in the nerves of *Helioporus pictus.*

We find Fig. 1, form ii., with nerve VIII., thickness 2, and Fig. 1, form iii., with nerve VIII., thickness 3, showing with an increase in thickness of nerve VIII. a corresponding advance in the composition of the ileo-hypogastric nerve comparable to that of *Hyla aurea.*

In the *cruralis* we have Fig. 2, form v., occurring with nerve VIII., thickness 2, and nerve IX., thickness 5, and form vii., with nerve VIII., thickness 3, and nerve IX., thickness 7. Thus we see that both the ileo-hypogastric and *cruralis* show here as in *Hyla aurea* a forward Homœosis in the origin of these two nerves, viz., from nerve IX. to nerve VIII., the ileo-hypo-

gastric preceding the *cruralis* because of its position nearer to the spinal column.

In Fig. 3 we find form ii. occurring with nerve VIII., thickness 2, nerve IX., thickness 5, nerve X., thickness 5, and nerve XI., thickness 2; and form iii. with nerve III., thickness 3, nerve IX., thickness 7, nerve X., thickness 7, and nerve XI., thickness 1—that is to say, as nerve VIII. increases, nerve IX. increases, and nerve XI. decreases, there is a decreasing tendency for nerve XI. to take any share in the formation of the sciatic. There is, therefore, here again a forward Homœosis. Nerve X. would seem to offer a slight difficulty in this respect, due probably to the small number of observations.

In Fig. 4 we see again an evidence of this same forward advance in the composition of the sciatic, and in the relations of nerve XI. to the leg, since form i. occurs with nerve XI., thickness 2, and form iii. with thickness 1 of nerve XI., nerve XI. it will be remembered being in a state of decrease.

In Fig. 5, form ii. occurs with nerve III., thickness 6, and nerve IV., thickness 3; and form iii., with nerve III., thickness 5, and nerve IV., thickness 6. Here we see that nerve III. appears to offer a slight deviation from *Hyla aurea*, since it decreases slightly in these few observations. On the other hand, however, nerve IV. increases greatly and as it does so takes an increasing share in the brachial plexus and therefore in the innervation of the fore-limb.

The results with reference to nerve II. are interesting. We find that in Fig. 6, form ii., nerve II. has thickness 3, and in form iii. it has thickness 4. If we premise, that as in *Hyla aurea*, II. is decreasing in thickness, then we have here, it would appear, an increasing connection of II. with the brachial plexus; but reference to Tables P and O will show that Fig. 6, form iii. is a very unusual form in *Hyla aurea*, so that we cannot attach much importance to this fact.

In *Limnodynastes tasmaniensis* we find the following thicknesses :—

Nerve.	Thickness.	Per cent.	Thickness.	Per cent.	Thickness.	Per cent.
II.	3	100	—	—	—	—
III.	5	66·6	8	33·3	—	—
IV.	3	33·3	4	33·3	7	33·3
V.	2	33·3	3	66·6	—	—
VI.	2	66·6	3	33·3	—	—
VII.	3	100	—	—	—	—
VIII.	3	66·6	4	33·3	—	—
IX.	5	100	—	—	—	—
X.	4	33·3	6	66·6	—	—
XI.	2	100	—	—	—	—

Nerve XII. is again absent.

All the specimens have the ileo-hypogastric composed of VIII. fibres only as in Fig. 1, form iii., *i.e.*, at its highest present state of advancement. When nerve VIII. has thickness 3, nerve IX. thickness 5, and nerve X. thickness 6, we find the *cruralis* in the condition drawn in Fig. 2, form v. It consists therefore of equal quantities of nerves VIII. and IX., with no other fibres; X. being absent. With nerve VIII. thicknesses 4 and 3, nerve IX. thickness 9, and nerve X. thicknesses 6 and 4, the *cruralis* finds its highest development, *i.e.*, it contains only fibres from nerve VIII. (*vide* Fig. 2, form viii.).

In all forms, the sciatic has also reached nearly its highest point of development as shown in Fig. 3, form iv., nerves IX. and X. sending equal quantities of fibres to it together with some from VIII. Nerve fibres from XI. are absent from the sciatic, that nerve (XI.) having reached its highest stage, as in Fig. 4, form iii. In the brachial plexus we find with nerve IV. thicknesses 7 and 3 and nerve III. thickness 5, nerve IV. is fused with III. for some distance, Fig. 5, form iv., while we get a branch between III. and IV., Fig. 5, form ii., with nerve III. thickness 8, and nerve IV. thickness 4. When we have nerve III. thicknesses 8 and 5, we find Fig. 6, form iii., *i.e.*, that II. is free from III., and with nerve III. thickness 5 we have a branch between II. and III., *i.e.*, Fig. 6, form iii.

The following observations were made on *Limnodynastes ornatus*. The thicknesses of the nerves were these:—

Nerve.	Thickness.	Per cent.	Thickness.	Per cent.
II.	3	100	—	—
III.	5	50	7	50
IV.	3	100	—	—
V.	2	100	—	—
VI.	2	100	—	—
VII.	2	100	—	—
VIII.	3	50	2	50
IX.	4	50	5	50
X.	5	50	6	50
XI.	2	100	—	—

Nerve XII. was not present.

The ileo-hypogastric always shows its highest development, Fig. 1, form iii. The *cruralis* has reached the stage in which it has only equal quantities of VIII. and IX. (cf. Fig. 2, form v.) We find Fig. 3, form iii., the sciatic being composed of IX. and X. fibres in equal quantities, with nerve VIII., thickness 2, nerve IX., thickness 5, nerve X., thickness 6, and nerve XI., thickness 2, and with the other thicknesses noted for these nerves, we find in addition to IX. and X. fibres, some of VIII. Nerve XI. is entirely absent from the sciatic, having reached its highest development, Fig. 4, form iii.

In the brachial plexus we find Fig. 5, form ii., with nerve IV., thickness 3, and nerve III., thickness 5, and form iii., with nerve IV., thickness 3, and nerve III., thickness 7.

Thus with an increasing thickness of nerve III. we get an increasing importance of IV. in the brachial plexus. Further with an increasing thickness of nerve III. we have an increasing connection of II. with this plexus, since with nerve III., thickness, 7, we have Fig. 6, form ii., and Fig. 6, form iii., with nerve III., thickness 5.

In the specimen of *Chiroleptes platycephalus* from Central Australia, which I examined, I found the following thicknesses: Nerve II., thickness 3, nerve III., thickness 11, nerve IV., thickness 5, nerve V., thickness 3, nerve VI., thickness 2, nerve VII., thickness 3, nerve VIII., thickness 4, nerve IX., thickness 8, nerve X., thickness 5, nerve XI., thickness 2. The ileo-hypo-

gastric was at its highest stage (Fig. 1, form iii.). The *cruralis* had the same relative position as in Fig. 2, form v. The sciatic only contained fibres of nerves IX. and X., as in Fig. 3, form iii., nerve XI. having the relations shown in Fig. 4, form iii.

In the brachial plexus, nerve IV. was in a highly advanced state, similar to Fig. 5, form iii., and nerve II. was quite free from the plexus as in Fig. 6, form iii.